Will the Population of Humanity in the Future be Stabilized?

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A phenomenological theory of growth of the population of humankind is proposed. The theory based on the assumption about a multifractal nature of the set of number of people in temporal axis and contains control parameters. In particular cases the theory coincide with known Kapitza , Foerster, Hoerner phenomenological theories .

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I. INTRODUCTION

The problem of mankind population growth is the one of the global problems concerning the development of the mankind and its future. Will the demographic explosion existing now at the mankind population of the whole world stop as already it has stopped in the most developed countries? Will the population of the Earth will be stabilized as it follows from S.Kapitza's theory (see [1])near 12 billions, or it will continue its growth at slower rate? What are the driving parameters that govern the development of mankind (such as presents in non-linear open system (see [2])? Are these parameters genetically predetermined or can they be changed and controlled by means of human activity? Stabilization of the mankind population of earth in the future is a sad prospect for mankind, because the absence of the numerical increasing of any biological population almost always leads, early or late, to cessation of any development (the examples are many species of insects, e.g. termites, frozen in development for millions years). Hence, the appearance of more active biological species becomes in that case quite probable. These active form of life will dominate the mankind and may force it out from its present ecological niche. The aim of the present paper is to introduce a new parameter in the phenomenological theories of humankind growth describing the development of mankind population if regard humankind as a large non-linear multifractal system. Namely, the fractal dimension of the whole mankind number in arbitrary moment of time - the local fractional dimension $d(t)$ (the fractional dimension for whole population of mankind). The introducing of this parameter allows to receive, as a special cases, the results of theories (see [1]), [3]- [4]), and several new scenarios of the mankind's future as well. Alongside with probable increasing of the mankind population, the scenario of ruin of the present civilization - diminution of its number down to zero - is shown to be possible. We note, that correct analysis of dynamics of multifractal sets (see [5]) requires the introduction of the mathematical concept of fractional derivatives (see [6]- [7]), which allow to take into account partly the memory of system about the past (in this case it is the memory, that includes genetic memory of mankind about its past development).

II. FRACTIONAL DIMENSION QUANTITY OF MANKIND ON TIME AXIS

We assume that the dynamics of the human population can be described within the framework of fractal geometry concepts and mathematical formalism of fractional differential equations (see [6]- [7]). For this purpose let us consider the set of all people as a multifractal set $N(t)$ $(0 \le t \le \infty)$ consisting of $N(t)$ of elements at the given time t. Following the Kapitza theory (see [1]), assume for a certain interval of time the existence of a self-similarity of this set characterized by its fractal dimension and introduce a local fractional dimension (LFD) $d(t)$ which describes the fractal properties of the set at the time t. This local fractional dimension is determined by those variables and their functions (these variables will be defined later) , that are treated as the driving (control) parameters of the human community development. Among such parameters there can be parameters of genetic origin (for example, probably, density of the population in cities per unit urban area, etc.) and "external" parameters (e.g., a possibility of supplying the mankind population of earth by necessary amounts of food, water and energy or quick climate changes or pollution of the environment and the atmosphere, etc.). We shall characterize an alteration of the mankind population $N(t)$ over a small time interval by the generalized fractional Riemann - Liouville derivative [7] (which coincides with the usual Riemann - Liouville derivative if d=const.)

$$D_{+,t}^{1+\nu(t)} N(t) = \frac{\partial^{\alpha}}{\partial t^{\alpha}} \int_0^t \frac{N(t')dt'}{\Gamma(\alpha - d(t'))(t-t')^{d(t')-\alpha+1}}, \quad (1)$$

$$d(t) = 1 + \nu(t) > 0$$

$$\nu(t) \equiv \nu(X_1(t), X_2(t)...X_i(t)), i = 1, 2, ..., \alpha = \{d\} + 1 \tag{2}$$

In (1) $\nu(t)$ is the fractional quantity and defines the differences between the derivatives of integer order and fractional derivatives (1) thus being the driving parameter for the growth of mankind as a whole, $\{d\}$ is equals to the integer part of $d(t) > 0$ $(\alpha - 1 \leq d(t) < \alpha)$, $\alpha = 0$ for $d < 0$, and the set X_i are the control parameters determining all external and internal influences on the mankind population growth .

The explicit information about the function ν and, hence, about LFD can be obtained only after a careful investigations and processing the statistical data of different events, circumstances and situations impact on the development of a human population. The fractional derivative using, as defined in (1), instead of the integer first derivative allows to introduce and take into account an obvious thing - a certain kind of mankind's memory of the past and memory about the development rates over the past years (integration with a weight function over all times till t beginning from a fixed moment). It gives a way of considering of different parameters X_i that influence at the mankind's development by means of LFD's dependence upon them. The present theory, as well as ([1]), is a phenomenological theory and the exact definition of function $\nu(t)$ form is beyond its scope. We note that it has sense to consider $\nu(t) \neq 1$, apparently, only for times greater than T_1' because before a certain time, introduced in ([1], [3]- [4]) (the time of demographic transition $T = T_1'$), the theories mentioned describe the empirical data about the number and progress of the mankind population quite well. Moreover, we shall restrict ourselves in this paper to analyzing growth of the mankind population for three special cases of $\nu(t) : \nu(t) = 0, \nu(t) = 1$ and $\nu(t) = -1$.

III. FOERSTER,HOERNER, KAPITZA THEORIES

It is known, that growth of the population of earth from ancient times untill now is well approximated by an empirical relation suggested by Foerster Von H. (see [3]) and improved by H. von Xoerner (see [4])

$$N(t) = \frac{C}{T_1 - T'}, \tag{3}$$

$$\frac{d(N(t))}{dt} = \frac{C}{(T_1 - T)^2} \tag{4}$$

$C = 2 \cdot 10^{11}, T_1 = 2025$

The reasonable generalization (3),(4) for future time (suitable for $T > T_1'$ that not gives as result an infinite value $N(t)$ for values $T = T_1$) was given in the phenomenological theory of the population S.Kapitza (see [1]) with the help of introducing of the mean people's lifetime τ (τ =42 of years). In this theory the relation for $N(T)$ (with C'=1,86$\cdot 10^{11}, T_1' = 2007$) takes place

$$\frac{\partial N(t)}{dt} = \frac{C'}{(T_1' - T)^2 + \tau^2} \tag{5}$$

From (5) the restriction of the mankind population of earth by quantity $14 \cdot 10^9$ follows. Unfortunately, the theory of the population S.Kapitza does not take into account neither exterior nor interior control parameters (even in simple form) basing only at the self-similarity of growth of a population of the people.

IV. GENERALIZATION OF FOERSTER, HOERNER AND KAPITZA THEORIES FOR MULTIFRACTAL SET OF A QUANTITY OF MANKIND $N(T)$

Let us assume the hypothesis about a fractal nature of set $N(t)$ (maintaining assumption about selfsimilar the sets $N(t)$). In that case derivative on time $\frac{\partial}{\partial t}$ in equation (5) should be substitute for fractional derivative $D_{+,t}^{1+\nu(t)}$. This operation take into account the memory of mankind about the past development. The right part (5) must be changed too for including in (5) an influence of the fractal dimension. So, instead of (5), obtain an equation

$$D_{+,t}^{1+\nu(t)} N(t) = \frac{C'}{|T_1' - T|^{2+\nu(t)} + \frac{2+\nu(t)}{2} \tau^{2+\nu(t)}} \tag{6}$$

The equation (6) can be considered as the basic equation of the phenomenological theory of development mankind's population offered in this paper. The selection of different functions of fractional corrections for $\nu(t)$ allows to estimate character of changing $N(t)$ as functions of time.

V. FORECASTS OF THE FUTURE DEVELOPMENT OF MANKIND POPULATION FOR SPECIAL CASES OF THE FRACTIONAL DIMENSION CHOICE

Some simple special cases forecasting of growth of the mankind's population of earth are considered below at the basis of the equation (6). The meanings a fractal dimension, for simplicity , chosen as integer.

a. Case $\nu(t) = 0$

At $\nu(t) = 0$ the fractional derivative D coincides with $\frac{\partial}{\partial t}$ derivative and the equation (6) coincides with equation (5) (hence, (6) includes S.Kapitza theory (see [1]) as a special case). It corresponds, probably, a compensation the positive and the negative control parameters X_i (including exterior and "interior" parameters), driving population of mankind.

b. Case $\nu(t) \to -1$

The selection $\nu(t) \to -1$ corresponds to a dominance of the negative tendencies in the future development of mankind and it is stipulated, for example, occurrence of irreversible changes in molecules DNA (owing to epidemic AIDS, etc.), irreversible cosmic cataclysmic (for example, drop on earth of meteorites of huge mass), impossibility for mankind to cope with negative factors of biogeozinos results in by effects of development of a technical civilization. In this case the equation (6) reduce to equation

$$N(t) = \frac{2C'}{2|T_1' - T| + \tau} \tag{7}$$

From (7) the presence of the maximum of number of mankind follows at $T = T'$ (i.e. in 2007) and it is equal $8,86{\cdot}10^9$ (if τ is not changed). After transition through a maximum $N(t)$ the number of mankind decreases (if the scenario will not vary) and in 2107 year $N(t)$ will be equal $1,54{\cdot}10^9$. By the year 3007 the number of mankind will decrease down to $182{\cdot}10^6$, i.e. the mankind population of all earth will be equal to number of the people is occupying a dozen of large modern cities. The complete degenerating of mankind, as a result of decreasing of mankind population in the considered scenario and subsequent leaving mankind from biological arena may be expected through millions years (not large time from biological point of view). By then population the mankind of earth will decrease up to several thousand.

c. Case $\nu(t) = -2$.

The equation (6) for this case is transformed into an integral equation at maintenance of the general tendency to accumulation of the negative factors resulting in to negative value $d(t)$. At negative values $d(t)$ the integral equation gives the prompt diminution of mankind population and extinction of existence of mankind as a species is follows. So, at $d(t) \to -1$ equations (6) transforms to a

$$\int_{T'}^{T} N(t)dt = C' \tag{8}$$

supposing the absence the mankind at the earth (in that case equation (8) has no solution for $N(t) \neq 0$ thou for $\nu > -2$ solution of equation (6) is exist (so $N(t) \to 0$ for $\nu \to -2$). The time interval (necessary for disappearance mankind) is determined in this case by time for which $d(t)$ will transfer from value equal to unity (status of mankind now) to value equal to negative unity. This time interval can be very short: from several years (cosmic cataclysmic) to about several centuries (virus pandemia with lethal change of a heredity, increasing of the mean temperature of earth on some degrees owing to throw out of carbonic gas etc.). It is necessary to pay attention on possibility of change of the negative scenario of mankind development stipulated by appearance and dominance of the positive control factors X_i (including those factors that due to conscious activity of mankind). In that case the inevitability of diminution of mankind population and destruction of mankind are not inevitable.

d. case $\nu = 1$.

We shall consider the optimistic scenario of change of mankind population. It relevant to a dominance of positive driving parameters: $d(t) > 1$. So, e.g. for $d(t) = 2$ ($\nu = 1$) from (6) the equation follows

$$\frac{\partial^2}{\partial t^2} N(t) = \frac{C'}{|T' - T|^3 + 1,5\tau^3} \tag{9}$$

The precise solution of an initial value problem of this equation is unwieldy, so we shall note , that at $T >> \tau$ the quantity $N(t)$ will increase faster then first degree of time ($N(t) \sim (T - T_1)$). The mankind population is increase and it characterizes in this case by following form (if there will not be includes appearance of a factors of conscious mankind activity which change the scenario and restricts unlimited growth of population)

$$N(t)|^{t\to\infty} \sim \frac{C'(T - T_1')}{2,29\tau^2} \ln \frac{(T - T_1')}{\tau} \tag{10}$$

So, at 3000 years, at the rate of increasing of the population defined by (10) (with the allowances that the corrections to $N(t)$ of value $ln[\frac{(T-T_1')}{\tau}]$ are dropped) population of mankind will increase up to 150 billions. That is improbable large, though, but it is may be not unreasonable because of future technical possibilities of mankind (probably, this number is the upper number for existence mankind population occupying the earth). For fractional values LFD $d(t)$, increasing or decreasing of a population of the mankind will be characterized by intermediate dependencies between the received for the whole values $d(t)$. In case of a periodic dependencies $d(t)$ from time the population of the world will change periodically depending on a concrete choice of d and $N(t)$ and will not be a monotonous function of time.

The examples are considered allow to determine the interval of change of fractional dimension $d(t)$ in reason boundary for number of quantity mankind in future: $-1 < d < 2$. The boundary values ($d = -1, d = 2$) are result in or to ruin of mankind, or to so large mankind population that Earth may not endure. The last case must result in to change of scenario and it consist in the change in correlation between positive and negative components of control parameters X_i towards increasing of influence of negative parameters.

Let the basic equation (6) is replaced by generalization of the S.Kapitza equation (5). Basic equation in that case reads

$$\frac{\partial^{1+\nu(t)}}{\partial t^{1+\nu(t)}} n(t) = K \sin^2 \frac{n(t)}{K} = \frac{1}{K}, \tag{11}$$

$$n = \frac{N(t)}{K}, t = \frac{T - T_1'}{\tau}, K = \sqrt{C'\tau^{-1}}$$

It gives for $N(t)$ the qualitative effects analogous to results obtained from the equation (6). So, in this connection, a selection for describing the future increasing the population of mankind by equation (6), as the basis, or equation (11), containing, as well as the equation (6), driving parameters X_i in fractional dimension $d(t)$, is not simple. As one of advantages of use of the equations (6) or (11) for describing demographic problems (with some of them the mankind already has confronted now) we shall stress an opportunity of insert and account in the theory many factors (such as , incurable illnesses, natural cataclysmic etc.) defining future of mankind as a result of influences the control parameters X_i (included in the dimension $d(t)$ of fractal set for number's distribution of the people in the time axis).

VI. CONCLUSIONS

1.The main purpose of this paper was to analyze possibility of introducing mankind's population driving parameters X_i in the phenomenological theories of the mankind population of the earth ([1], [3], [4]) by method of attributing to set of the people $N(t)$ the fractional dimension $d(t)$, depending from these parameters. At a choice $d(t) = 1$ the numbered theories are a special case of this phenomenological theory. The consideration of examples with integer meanings of $d(t)$ is caused only by their mathematical simplicity and gives a reasonable meaning of fractal dimensions $(-1 < d < 2)$ for describing the time dependence of population of mankind.

2. In case when the interpretation the fractal properties of set of the homosapience given in this paper corresponds to a reality, (more real cases correspond to fractional meanings $d(t)$) the future of mankind is not so mournful as in the case of the S.Kapitza theory (see [1]) and the exposition of change of number of mankind within the framework of the phenomenological theories of the population can be reduced to a selection of control parameters and filling them by the concrete contents.

3. The change of number of mankind (described in the framework a phenomenological theories of the population) can be adjusted by such choice of control parameters (and filling the fractal dimension $d(t)$ by the concrete contents of dependencies of them) at which the population of mankind will grow so slowly, that overpopulation and the problems connected with it will do not arise in the foreseen future. Last will allow the theory be more realistic for predicting and menaging the future growth population of mankind as one of biological species occupying our world.

4. The growth of mankind population regulation (included in the parameters X_i) will allow to avoid degenerating of mankind and to keep as much as long time the main ecological niche at Earth occupied by mankind. Last will give time for more realistic forecasting of the future mankind as one of biological kinds occupying our world.

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